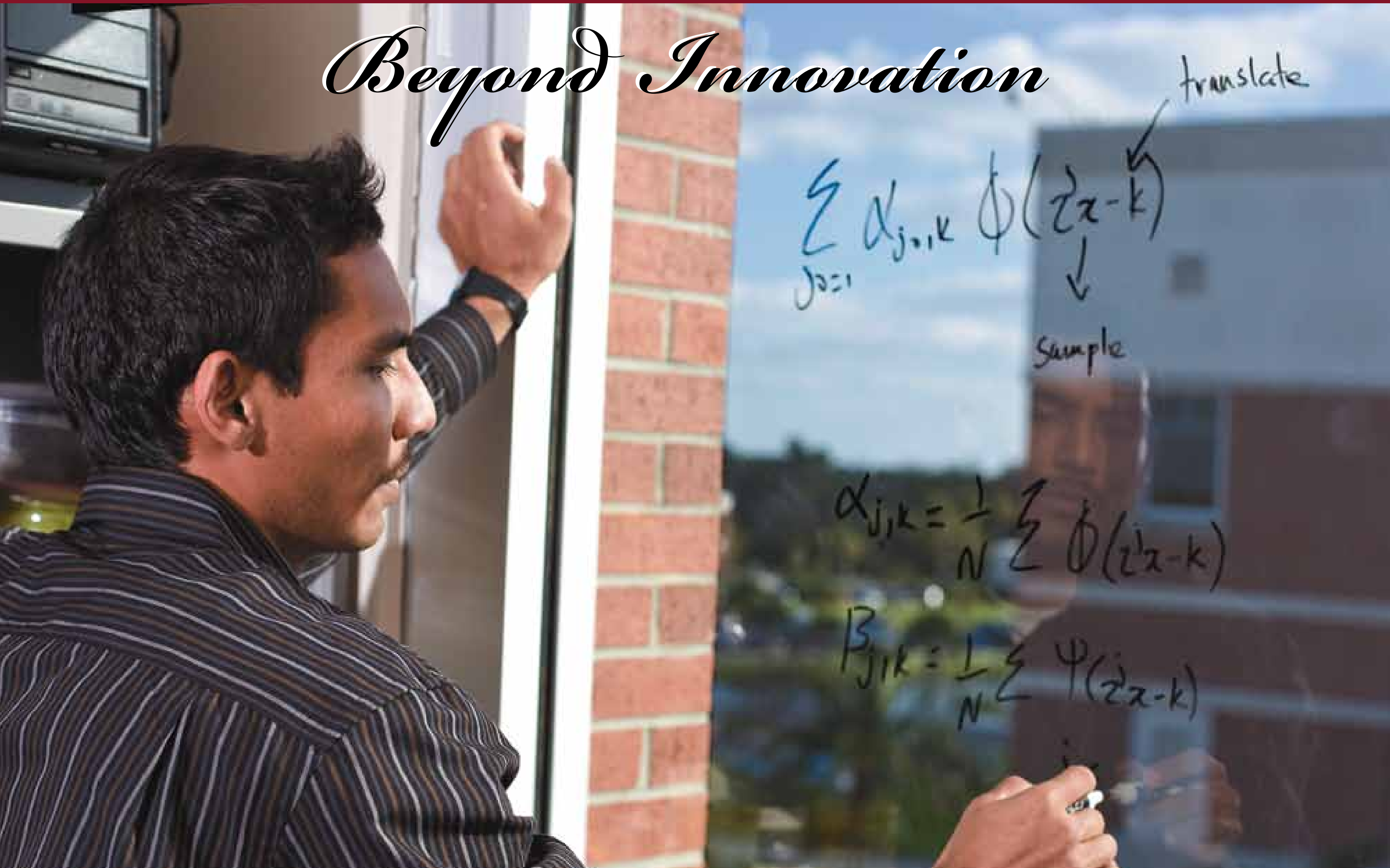
Florida Institute of Technology
High Tech with a Human Touch™

Beyond Innovation



FLORIDA TECH ENGINEERING

Florida Tech Engineering Goes Beyond In

This year's College of Engineering annual report highlights two senior design projects, two major laboratories and one of our highly successful alumni. These stories are examples of how the College of Engineering at Florida Tech goes beyond innovation.

novation ... 2011–2012 Annual Highlights

Students

Students put to use classroom instruction and laboratory experiences when they embark on their senior design projects. The two student design projects highlighted in this Florida Tech engineering annual report, the Lunabot and Hurricane-Tornado Home Monitoring System, typify how truly innovative our students can be. Their creative ideas can be carried out beyond the final project presentation at the annual design showcase in April. Some of our graduating senior design team members, for example, form their own corporations while others have filed patent applications. All student teams begin, however, with innovative ideas for senior design projects, which can arise in many ways, such as from faculty advisers or the students themselves. Local companies may be involved directly by offering their ideas for projects, and in some cases, company engineers will assist the students in the design process. In the case of the Lunabotics project, for example, the team will compete at Kennedy Space Center's Lunarena in May of this year.

An additional advantage for our students engaged in senior design projects is that they can acquire international experience. At least 106 countries are represented on the Florida Tech campus. Engineering student design teams may count membership from among a variety of countries and cultures. This rich experience contributes to educating engineering leaders of the future who are ready to make their place in the world.

Faculty

The College of Engineering laboratories highlighted in this year's report represent two relatively new and very progressive labs where taking research beyond innovation is the norm.

The Applied and Computational Electromagnetics Laboratory, headed by Brian Lail, associate professor of electrical and computer engineering, works on various technologies that are destined to make a significant engineering impact. Projects carried out in his lab range from how we can view images through fabric and sand using a low-cost passive millimeter-wave device, to a collaborative effort that has led to a near-field optical vector network analyzer used to extract impedance properties of optical antennas. Already recognized for his expertise, Lail won the prestigious Presidential Early Career Award for Scientists and Engineers (PECASE) in 2008.

The Information Characterization and Exploitation (ICE) Laboratory is co-directed by Georgios Anagnostopoulos, associate professor of electrical and computer engineering, and Adrian Peter, assistant professor of engineering systems. In their research, they examine large volumes of data by conducting detailed analysis leading to a better understanding of information which is paramount today. The ICE lab is about applying the principles of machine learning to exploit the structure and various relationships in data sets. The bottom line for the researchers in the ICE lab: How can we transform an abundance of data into defined decision tools that can be used by individuals who have to make important, quick decisions?

Alumni

Sungjin Park was not only a very inquisitive and technically excellent Ph.D. student at Florida Tech, he also had a yearning for entrepreneurship. This strong desire for starting his own business is now manifested in a leading embedded software company, The Vine Corporation, with Park as the president and COE. The company's software solutions for quality of voice for cell phones have advanced the intelligibility of speech for all users, especially those who are hearing impaired. He has also developed the Neural Perceptron 3 (NP3) technology that can restore natural sound, especially when applied to music.

These are just two examples of the technological advances that have been created at Park's company. He is one of our graduates who knows what it takes to go beyond innovation.

On a final note, I look forward to sharing, in the near future, the details pertaining to the newly formed Center for Space Commercialization and our Biomedical Program in the College of Engineering. I hope you enjoy reading about these students, faculty members and an alumnus in this issue of the Florida Tech Engineering annual report.

Fredric M. Ham, Ph.D.
Dean, College of Engineering | Harris Professor
fmh@fit.edu

Lunar Mining?

Build a Robot to Do the Job

Some students tackle their culminating project with an eye to competition. Allison Metzger is one such student. The senior mechanical engineering major leads her five-member team building a robot for NASA's Lunabotics Mining Competition. The competition's catchphrase is "Design it. Build it. Dig it." Metzger's team has #1 down and is getting set to build its Lunabot for the May 21–26, 2012, event at Kennedy Space Center's Lunarena.

In its third year, the event is designed to engage and retain university students in science, technology, engineering and mathematics. The students develop innovative lunar excavation concepts that could result in ideas and solutions applicable to actual lunar devices. In 2012, over 70 teams will compete from all over the world.

The teams build an excavator—the Lunabot—that can mine and deposit a minimum of 15 kilograms of simulated lunar dust within 10 minutes. Students are challenged by the weight and size limitations of the Lunabot and the ability to telerobotically or autonomously control it from a remote mission control center. Teams are scored on a variety of design and operation factors, such as dust tolerance and projection, communications, vehicle mass, energy or power requirements and level of autonomy. The Lunabots are also judged on the amount of material excavated in the allowed time. This year they will shovel up volcanic material brought in from fields near Flagstaff, Ariz.

"'Conquering' the moon implies the development of technologies that will enable future human presence on the moon. This could be for mining, refueling of spacecraft and several other operations envisioned by NASA and other space agencies. The Lunabotics competition raises awareness of these needs and poses a few of these questions as a challenge for future generations of engineers," said Hector Gutierrez, Ph.D., the team's faculty adviser.

Metzger's team has many fans rooting for it in a way that matters the most to young engineers—funding support. The Missile Range and Space Pioneers, an organization of retired engineers from Kennedy Space Center and early missile range, donated $4,000. The Florida Tech College of Engineering contributed another $7,000. "This support pretty much covered the cost of all our material and parts," said Metzger.

"The best part of this project is starting from scratch. Only one Florida Tech team has previously entered the competition," she said. "We're taking our creativity, knowledge and innovativeness and going through all the steps they've taught us in school. We work as a team, putting our ideas together."

With the design complete, the next step is a cardboard model. Each team member has a job to do. Metzger's role in building the robot is to set up the wheels and control functionality of the arm.

When it all comes together as planned in the competition, the grand prize will be $5,000 in scholarship money and up to $1,000 in travel expenses for each team member and faculty adviser to participate in a NASA remote research and technology test. Then, of course, there are bragging rights.

"It will be a challenge for this hard-working, enthusiastic team," said Gutierrez. "All students in this team are mechanical engineering majors and many of the problems to solve are electrical, electronic and software related. They will definitely be learning a lot as they build their robot."

Use your smartphone to scan this QR code to view a video!

Nano-Research:

The Applied & Computational Electromagnetics Laboratory

In 1959, prior to receiving the Nobel Prize in physics, Richard Feynman gave a lecture at an American Physical Society meeting at the California Institute of Technology entitled "There's Plenty of Room at the Bottom." In this talk, Feynman provided a glimpse into the potential impact and challenges of "manipulating and controlling things on a small scale."

He noted numerous possibilities, including nanoscale circuits, the concepts of nanoimprinting and electron beam lithography, and nanoscale antennas, among others, albeit without using these terms that have since become accepted as the field of nanotechnology has developed.

Over 50 years later, nanoscale electromagnetics, or nano-optics, is a vibrant area of fundamental and applied research. The underlying physical laws governing electromagnetic interactions, in fact, must now be reconsidered at the nanoscale. Unique properties, such as the ability to focus light into sub-wavelength dimensions and the inherent coupling of radiation with the electronic and vibrational transitions in matter, provide fertile ground for technological advancements in imaging, spectroscopy and communications within systems that are lighter, smaller and cheaper to build.

The Applied and Computational Electromagnetics Group conducts research in detecting and manipulating electromagnetic fields with emphasis on the nanoscale. The Lail group considers the design and analysis of antennas and periodic structures with proficiency in numerical electromagnetic modeling, as well as fabrication and testing.

The Department of Justice (DOJ), Defense Advanced Research Projects Agency (DARPA), National Aeronautics and Space Administration (NASA), Office of Naval Research (ONR), National Science Foundation (NSF) and Raytheon Vision Systems support this work. In December 2008, in recognition for this effort, I received the Presidential Early Career Award for Scientists and Engineers (PECASE) in a ceremony at the White House.

Selected research examples

In the millimeter-wave (mmW) spectrum, electromagnetic fields can penetrate obscurants, such as dust or fog. Recently, there has been a push to develop low-cost passive mmW imagers for this purpose. A spiral antenna design, coupled to a Schottky diode, for operation over frequencies over 75-400 GHz, was demonstrated to image through fabric and sand. Dual-band, mmW and infrared (IR), passive imaging arrays of antenna-coupled detectors make possible smaller, lighter and cheaper imagers with the unique ability to switch between imaging through obscurants (mmW) and thermal imaging (IR).

Detecting infrared radiation is a fundamental requirement for thermal imaging, facilitated by advances in lithographic technology, which make possible the fabrication of infrared and optical antennas. Inspired by radiofrequency antenna technology, my group designs and characterizes nanoscale resonant structures and antennas. Although antenna-coupled detectors, such as microbolometers and diodes, show potential for novel next-generation IR imagers, challenges must be met to implement these techniques into focal-plane arrays.

To assess the coupling between IR antennas and detectors, my colleagues—Glenn Boreman of the University of North Carolina at Charlotte and Markus Raschke of the University of Colorado at Boulder—and I have developed a near-field optical vector network analyzer that can be used to extract impedance properties of optical antennas and devices. This technique is expected to provide valuable insight into the design constraints of optimal power transfer to the detector. The implementation of impedance surfaces—those that contain a periodic array of conducting elements that govern the interaction with incident fields—have been demonstrated as frequency-selective surfaces and reflect arrays, and prove useful for enhancing impedance-matching to IR absorbers. By tailoring the layout, IR waveguides and holographic antennas are under investigation for IR applications that exploit the surface-wave propagation on these surfaces.

As Feynman foresaw in 1959, great discoveries and technological advancements have resulted from the study of nanoscale interactions. Formerly novel areas of nanoscience have become commonplace and the study of nanoscale electromagnetics has seen rapid progress. The Lail group and researchers in the Applied and Computational Electromagnetics lab at Florida Tech recognize the impact potential of fundamental and applied nanoscale electromagnetics research. We all enthusiastically pursue further collaborations and research opportunities in this field.

Brian Lail, Ph.D.
Associate Professor
Computer and Electrical Engineering

About Brian Lail

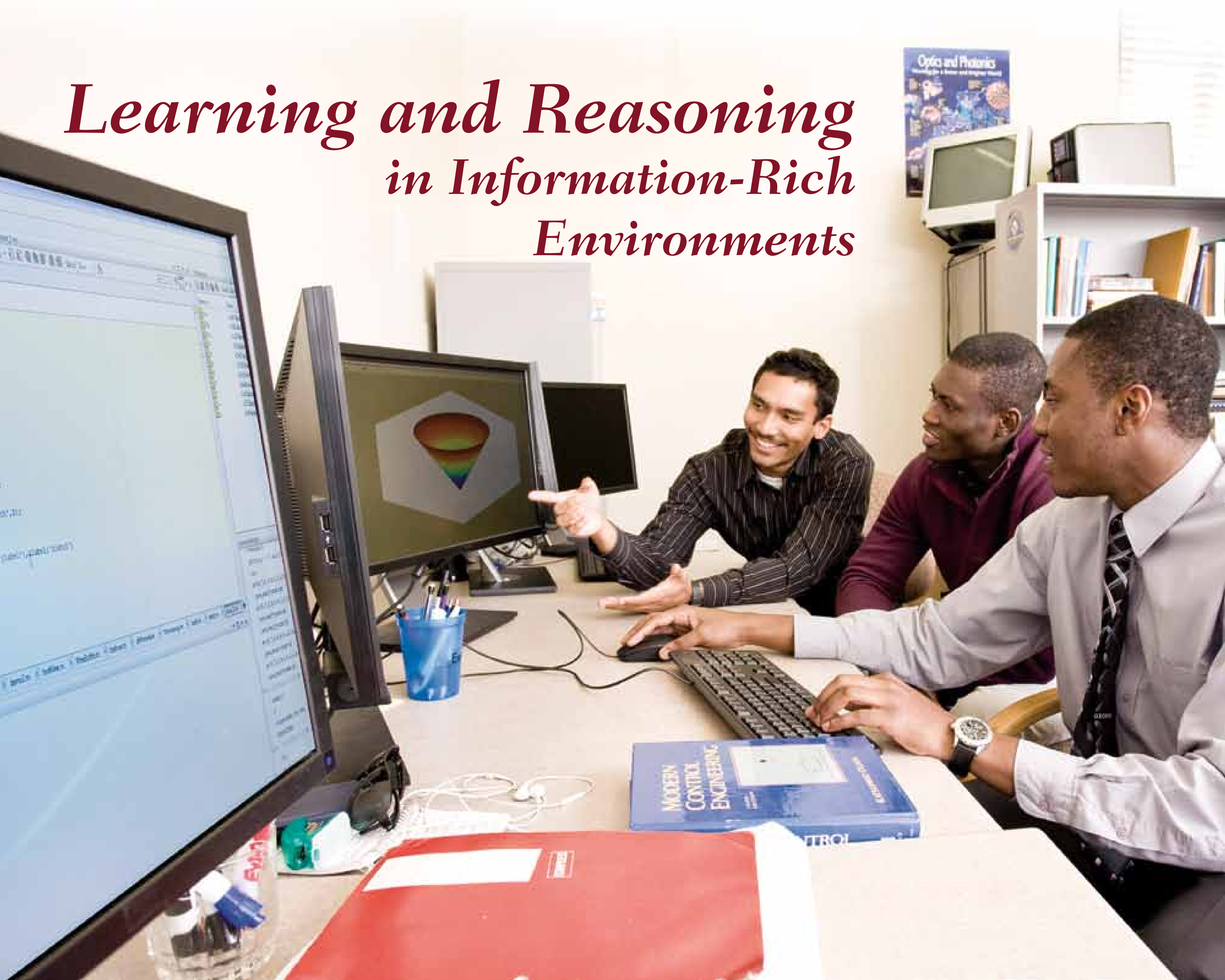
Brian Lail received the prestigious Presidential Early Career Award for Scientists and Engineers (PECASE) from the Department of Defense at a White House ceremony in December 2008. This is the nation's highest honor for professionals at the outset of their independent scientific research careers. A principal investigator in numerous funded projects, Lail in 2010 earned the Florida Tech Faculty Excellence Award for his research.

Prior to joining the Florida Tech faculty, he was a visiting assistant professor in the department of electrical and computer engineering at the University of Central Florida in Orlando, where he conducted funded research.

He earned master's degrees in physics and electrical engineering from New Mexico State University and a doctoral degree in electrical engineering from that institution.

Brian Lail, left, with graduate students in the Applied and Computational Electromagnetics Group conduct research in detecting and manipulating electromagnetic fields with emphasis on the nanoscale.

Learning and Reasoning in Information-Rich Environments



In the 1960s technologists predicted that we were on the path to a global information age. Fifty-plus years later, the overwhelming consensus is that we have surpassed these forecasts and now are drowning in information. Information is being generated at unparalleled rates, from a plethora of sources: mobile devices, personal computers, commercial and military sensors, medical devices, wearable computers, etc.

This deluge is shifting the demand function from information acquisition and creation to information analysis and understanding. The Information Characterization and Exploitation (ICE) Laboratory at Florida Tech is actively researching solutions to automate analysis and decision support in the face of these information processing challenges.

Our research is most closely aligned with the discipline of machine learning (ML). A subfield of artificial intelligence, ML studies, analyzes and develops new models and associated algorithms that facilitate the process of learning to perform hard computational tasks from usually limited experimental evidence and a variety of information sources. Examples of such tasks are recognizing objects (classification), detecting events/occurrences of importance/interest (detection), learning associations between causes and effects (regression), discovering structure and relationships in data (clustering, data mining), and many others. Machine learning also incorporates methodologies such as robust statistical data analytics, data visualization and physically motivated mathematical models to develop novel data exploitation algorithms. These are all key technologies that can transform raw information into timely decision aids for users such as business managers, policy makers or military commanders.

Recently the lab has focused on four research areas: kernel-based machine learning, computational information geometry (IG), evolutionary computation (EC), and quantum information processing (QIP).

Kernel-based learning uses suitable kernel functions that attempt to quantify the degree of similarity between data samples. Data are first implicitly mapped into a new feature space specific to the choice of the kernel function. Then the ML task, such as a recognition or regression problem, is solved in the new feature space instead of in the data's native space, which may offer computational advantages (the problem is easier solved) or even allow discovery of better solutions. Recent projects in this area include efficient Support Vector Machine (SVM) training algorithms, SVM-based target recognition from Synthetic Aperture Radar imagery, outlier detection based on how data are distributed in the kernel principal subspace, kernel-based metric multidimensional scaling for manifold learning, data visualization and exploratory data analysis, and the development of Multi-Kernel Learning algorithms for Multi-Task ML.

Computational information geometric approaches are at the bleeding edge of ML modeling. The IG learning strategies capture trends and structures in the observational data by characterizing them with probabilistic models. IG then brings together principles from information theory, probability theory and differential geometry to form a unified approach to tasks such as inference and clustering, where the analysis is carried out on the mathematical manifold of our data probability distributions. This gives intuitive geometric interpretations and rigor to the analysis results, allowing one to work in the natural geometry of the data. We are currently developing IG-based, novel-shape matching algorithms, wavelet density estimators and geometrically motivated model selection methodologies.

Our efforts in EC (evolutionary computation) and QIP (quantum information processing) are our latest thrusts. EC methods are stochastic meta-heuristics for classical and combinatorial optimization, either of a single objective or even multiple, often conflicting, objectives. Past efforts have centered primarily on neuro-evolution, which deals with evolving high-performing artificial neural networks. However, our recent focus also targets more fundamental contributions to EC methods, such as Particle Swarm Optimization. On the other hand, QIP brings to bear the physically motivated formalisms of quantum mechanics on the problem of information exploitation. We are currently developing a novel approach to the classical path planning problem by casting it as a solution to the Schrödinger wave equation. In addition, new investigations involve the use of Hamiltonian operators for sensor modeling and fusion.

The ICE Lab routinely collaborates with leading universities around the world. Besides United States collaborations, recent partners include researchers from the United Kingdom, Greece, Germany, Italy and Japan. While some projects have received funding from traditional government sources, such as the National Science Foundation, we also execute funded projects from our close industry partners such as the Harris Corporation. The ICE Lab is co-directed by Georgios C. Anagnostopoulos, department of electrical and computer engineering, and Adrian M. Peter, department of engineering systems. For more information about the lab: http://research2.fit.edu/ice.

Georgios C. Anagnostopoulos, Ph.D., associate professor, electrical and computer engineering and Adrian M. Peter, Ph.D., assistant professor, engineering systems

Use your smartphone to scan this QR code to view a video!

About Georgios C. Anagnostopoulos and Adrian M. Peter

Georgios C. Anagnostopoulos joined Florida Tech in 2003. He was previously a visiting assistant professor in computer science at the University of Central Florida in Orlando and worked in industry as a software engineer for Technisource Inc. and Lucent Technologies Inc., both in Orlando. A senior member of the Institute of Electrical and Electronics Engineers, he received Florida Tech's Kerry Bruce Clark Award for Excellence in Teaching in 2007. His research outcomes have been featured in more than 80 conference papers (some of them invited), journal papers and book chapters. He has also been the principal investigator for National Science Foundation grants.

He earned his doctoral degree in electrical engineering from the University of Central Florida.

Adrian M. Peter is also a faculty researcher in Florida Tech's Center for Space Commercialization, which was launched in 2011. He has delivered numerous professional papers; this includes a presentation at the 2011 International Conference on Computer Vision. Peter was previously chief scientist, Advanced Analytics Group, at Northrop Grumman in Melbourne, Fla. Peter was also a software engineer at Harris Corp.'s Government Communications Systems Division in Melbourne, Fla., where he was co-inventor on eight patents, and was a communications/networking initiative manager at Intel Corp in Chandler, Ariz.

He earned a doctoral degree in electrical and computer engineering from the University of Florida.

Alumnus Sungjin Park Has an Ear for Sound

Sungjin Park '03 Ph.D., president and CEO of The Vine Corp, is a connoisseur of sound. It all began when he was in middle school and wanted a Mark Levinson audio system.

"It was tops in the 1980s, but it was so expensive, of course I couldn't buy it," Park said. Instead he bought a lower priced system. Sadly, it was soon on the blink, and he was unable to get it fixed because of the expensive repair cost.

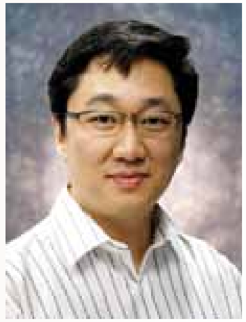
Park later went on to a university in his native South Korea and majored in electronics engineering. In an introductory course for freshmen, he told his instructor that he had come to the university so he could fix his stereo.

"Of course, I did fix the sound system myself, and my audio career started from that point," Park recalled.

Today his company creates software algorithms to improve the voice quality of mobile phones and electronic devices. He launched his first major product in 2009, the Voice Clarity solution for selected mobile phones. This and related speech enhancement software technologies have since become very popular and are now embedded in more than 20 million mobile phones.

"Voice Clarity solves the problem of ambient noise communication disturbances," said Park. "It enhances voice quality in mobile phones through a patented consonant-restoration technology, which dramatically enhances the intelligibility of speech and audio signals that are received in mostly noisy environments. The solution is based on mathematical algorithms and much research in psychoacoustics and speech perception."

Prior to founding The Vine, Park worked for 10 years at electronics firms where he directed or co-directed major R&D projects in Israel, India, Russia, Switzerland and the U.S. Also, in 2003–2004, he was a visiting professor at Florida Tech, teaching electrical circuits and conducting research for The Boeing Company with Fredric Ham, now dean of the College of Engineering.



Sungjin Park '03 Ph.D.

Throughout his career, he has been recognized for his contributions and industry leadership. In 2011, he received the Men of the Software Industry Merit Award from the South Korean Ministry of Knowledge and Economy (*below*). He also earned the Authentication of Merit from the governor of South Korea's Gyeonggi Province in 2011. In 2010, Park was named Outstanding Alumnus in the College of Engineering at Florida Tech.

Today a Mark Levinson audio system is likely within Park's financial reach. Better than that, though, while working in industry he met Levinson.

"Now, he and I are the best of friends," said Park. "Just yesterday we had a Skype chat for three hours."

He didn't mention the quality of the sound.

Hurricane Inspires Student Design

When Christopher Andre, computer engineering senior, was living on Florida's southwest coast in Naples, he felt the power of a hurricane first-hand. Andre vividly recalls when as a 15-year-old he saw Hurricane Katrina blow by on her way to New Orleans. Luckily, his home and family never suffered major damage from Katrina or other tropical storms, just power loss and broken trees. Still, his interest in extreme weather was piqued. He thought a useful device would be a home monitoring system that could let users know, while away, the status of their homes when subject to hurricanes or tornados. Thus, his idea for the Hurricane-Tornado Home Monitoring System was born.

For his culminating design project, Andre teamed up with Ivica Kostanic, Ph.D., associate professor of electrical engineering, who was working with the mechanical and civil engineering departments on a National Science Foundation (NSF) funded project related to hurricane monitoring on Florida's East Coast. Andre's project complements this effort. He is developing a new hurricane sensor system that wirelessly sends important hurricane data to a central location where researchers or emergency personnel can monitor the hurricane's progress. The system uses three sensors and a data transfer system that primarily consists of a microcontroller, an Xbee wireless radio and a central computer system.

The water sensor detects the presence or absence of water throughout the home. The information goes through a radio-frequency (RF) radio and the data is transmitted to the wireless gateway. The software-driven microprocessor is the core of the broken glass sensor, using high-frequency sound pressure and a digital filter to detect the presence of broken glass in the home. The third sensor, the accelerometer, senses wind velocity, or G-force, and could also relay information about seismic tremors.

"To my knowledge there are no products on the market like mine and it's simple to use," says Andre. "It's satisfying to know my project is one of a kind and that it can actually help people."

He's not the only one who's enthusiastic.

"Chris's senior design project is a logical extension of the wireless sensor system developed at Florida Tech," says Kostanic. "His device can collect additional information about real-time behavior of man-made structures that are exposed to hurricane winds. Such information is vital in developing codes and construction practices that will reduce the damaging effects of the hurricanes. We are all very eager to have the system operational and available for the next hurricane season."

Project

"It's satisfying to know my project is one of a kind and that it can actually help people."

Chris Andre

COLLEGE OF ENGINEERING

ENGINEERING SIGNATURE RESEARCH AREAS

Sustainability of the Environment • Intelligent Systems • Assured Information and Cyber Security • New Space Systems and Commercialization of Space • Communication Systems and Signal Processing • Biomedical Systems

Florida Institute of Technology **http://coe.fit.edu**

EN-062-112